ANNUAL PROGRESS REPORT

GRANT NO:	N00014-98-1-0570
PR NUMBER:	98PR05446-00
P.O. CODE:	312
DISBURSING CODE:	N68892
AGO CODE:	N62879
CAGE CODE:	1W324
PRINCIPAL INVESTIGATOR:	Gerardo Morell (gmorell@rrpac.upr.clu.edu)
INSTITUTION:	University of Puerto Rico
GRANT TITLE:	Semiconducting Diamond for Electronic Applications
REPORTING PERIOD:	01 May 1998 - 30 April 1999
AWARD PERIOD:	01 May 1998 - 30 April 2001
CO-PRINCIPAL INVESTIGATORS:	Brad R. Weiner, Antonio Martinez
GRADUATE STUDENTS:	Juan A. Gonzalez, Osvaldo Figueroa, Sanju Gupta
UNDERGRADUATE STUDENTS:	Iris M. Vargas, Jalice Manso, Jose Guzman

OBJECTIVE: To fabricate high-quality polycrystalline diamond thin films and to dope these films with Li/Na in order to obtain n-type semiconducting behavior.

APPROACH: A hot filament chemical vapor deposition reactor is employed to deposit polycrystalline diamond films. A study of the parameter space is underway in order to determine the optimum deposition window. The smart application of *in situ* monitoring of the growing surface through ellipsometry measurements allows to expedite the study of the parameter space and to characterize the effects of changes in the processing parameters over film quality in real time. Doping will be attempted once the film quality is optimized, in order to reduce to a minimum those effects that mask/hinder the semiconducting behavior being sought.

ACCOMPLISHMENTS (last 12 months): We have successfully interfaced a spectroscopic ellipsometer to our chemical vapor deposition (CVD) system for the *in situ* monitoring of the diamond film deposition process. We have also interfaced our CVD to the emission port of a FTIR spectrometer in order to monitor *in situ* the gas phase species just above the substrate through their infrared emission. The study of the parameter space was already started before the *in situ* characterization tools were interfaced. This allowed us to fine tune our custom CVD system and to narrow down the parameter window of interest.

SIGNIFICANCE: The combination of two *in situ* techniques, one for the growing film (spectroscopic ellipsometry) and one for the gas species (infrared emission) serving as raw materials, will help elucidate the underlying mechanism for diamond film growth under CVD conditions and will lead to an optimized diamond film fabrication technique.

WORK PLAN (next 12 months): The infrastructure for the *in situ* monitoring of the CVD process that we have built during the first year of this proposal is a major advantage in diamond film research. The research plan for the second year is to employ our custom *in situ* characterization research tools in the exploration of the parameter space of our CVD. An optimized deposition window shall be found and characterized that yields diamond films of high crystalline quality, minimal concentration of non-diamond components, (100) morphology, and good surface coverage.

PUBLICATIONS, ABSTRACTS, TECHNICAL REPORTS, AND PATENT DISCLOSURES OR APPLICATIONS (last 12 months):

Papers Submitted:

1. *The microstructure of diamond thin films grown by electron cyclotron resonance-assisted chemical vapor deposition*, S. Gupta, R.S. Katiyar, D.R. Gilbert, R.K. Singh, and G. Morell, submitted to Physical Review B.

2. *Effects of low temperatures, low pressures and seeding over the crystalline quality, yield and stress of diamond films grown by ECR-assisted chemical vapor deposition*, G. Morell, S. Gupta, R.S. Katiyar, D.R. Gilbert, R.K. Singh, submitted to Journal of Materials Research.

Papers Published:

1. *Study of Diamond Films Grown at Low Temperatures and Pressures by ECR-Assisted CVD*, S. Gupta, G. Morell, R.S. Katiyar, D.R. Gilbert, R.K. Singh, Diamond and Related Materials 8, pp. 185-189 (1999).

2. *In Situ Measurements of Methane and Acetylene Concentrations In A CVD Reactor by Infrared Spectroscopy*, G. Morell, E. Canales, and B.R. Weiner, Diamond and Related Materials 8, pp. 166-170 (1999).

3. *Measurement and Analysis of Diamond Raman Bandwidths*, G. Morell, O. Quiñones, Y. Diaz, I.M. Vargas, B.R.Weiner, and R.S. Katiyar, Diamond and Related Materials, 7, 1029 (1998).

Conferences:

1. Participation in the Gordon Conference on Diamond Synthesis held in Oxford, United Kindom, August 22-29, 1998. During this conference the work entitled *In situ Infrared Spectroscopy of Methane and Acetylene in a Chemical Vapor Deposition System* by G. Morell, E. Canales and B.R. Weiner was presented.

2. The following titles correspond to presentations given at the Centennial American Physical society Meeting held in Atlanta, Georgia, March 20-26, 1999:

    a. *Study of the Effects of Changes in the Growth Conditions over the Microstructure of Diamond Films Prepared by Filament-Assisted Chemical Vapor Deposition,* J.A. Gonzalez, O. Figueroa, I.M. Vargas, B.R. Weiner, G. Morell

    b. *Controlling the Diamond Film Microstructure by Seeding Density,* S. Gupta, G. Morell, R.S. Katiyar, D.R. Gilbert, R.K. Singh

    c. *Study of the Carburization of Tantalum Filaments Employed in the Chemical Vapor Deposition of Diamond,* J.A. Gonzalez, O. Figueroa, I.M. Vargas, B.R. Weiner, G. Morell

3. Participation in the EPSCoR 1999 Meeting, 30 April - 2 May, Ponce, Puerto Rico, *Study of the effects of changes in the growth conditions over the microstructure of diamond films prepared by filament-assisted chemical vapor deposition,* G. Morell, J. González, O. Figueroa, I.M. Vargas, J. Manso and B. R. Weiner.

4. Participation in the XXIII Latin American Chemistry Congress, 26-31 July 1998, Rio Grande, Puerto Rico, presentation entitled *Chemical Vapor Deposition of Diamond Thin Films,* G. Morell and B.R. Weiner.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT DATE	3. DATES COVERED *(From - To)*
15-10-1999	Technical Annual	01-May-98 to 30-April-1999

4. TITLE AND SUBTITLE
Semiconducting Diamond for Electronic Applications

5a. CONTRACT NUMBER

5b. GRANT NUMBER
N00014-98-1-0570

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Gerardo Morell (PI)

5d. PROJECT NUMBER
98PR05446-00

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
University of Puerto Rico
Río Piedras Campus

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Sponsoring Agency: Department of Defense-Ballistic Missile Defense Organization
Mentoring Agency: Office of Naval Research (Dr. C. Wood)

10. SPONSOR/MONITOR'S ACRONYM(S)
DoD-BMDO/ONR

11. SPONSORING/MONITORING AGENCY REPORT NUMBER

12. DISTRIBUTION AVAILABILITY STATEMENT
Approved for Publid Release

13. SUPPLEMENTARY NOTES

14. ABSTRACT This research work aims at fabricating high-quality polycristalline diamond thin films and at doping these films with Li/Na in order to obtain n-type semiconducting behavior. A hot filament chemical vapor deposition reactor is employed to deposit polycrystalline diamond films. We have successfully interfaced a spectroscopic ellipsometer to our chemical vapor deposition (CVD) system for the in situ monitoring of the diamond film deposition process. We have also interfaced our CVD to the emission A study of the parameter space is underway in order to determine the optimum deposition window.

15. SUBJECT TERMS
Wide bandgap semiconductor, diamond film, chemical vapor deposition, doping, n-type conductivity, ellipsometry, infrated emission

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Gerardo Morell
U	U	U	UU		19b. TELEPONE NUMBER *(Include area code)* 787-645-0685